



FAA-E-2429  
January 2, 1970

# DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION SPECIFICATION

## ANTENNA SYSTEM, GLIDE SLOPE

### 1. SCOPE AND CLASSIFICATION

1.1 Scope.- This specification sets forth requirements for transmitting antenna systems designed to operate in the frequency range of 328.0 to 336.0 MHz suitable for use at null reference and capture effect glide slope stations. These antenna systems utilize directional antenna arrays with integral pickup devices and signal combining networks for monitoring purposes.

1.2 Classifications.- Two classes of antenna systems are covered by this specification as follows:

Class 1	Null reference
Class 2	Capture effect

### 2. APPLICABLE DOCUMENTS

2.1 FAA specifications.- The following FAA specifications, of the issues specified in the invitations for bids or requests for proposals, form a part of this specification:

FAA-D-638	Instruction Book, Electronic Equipment
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**FAA-G-2100/1 Electronic Equipment, General Requirements  
for all Equipments**

**FAA-G-2300 Panel and Vertical Chassis, Rack**

**2.2 FAA standard.-** The following FAA standard, of the issue specified in the invitation for bids or request for proposals, forms a part of this specification:

**FAA-STD-012 Paint Systems for Equipment**

(Copies of this specification, and of other applicable FAA specifications, standards and drawings, may be obtained from Federal Aviation Administration, Washington, D. C. 20590, Attn: Contracting Officer.

Requests should fully identify material desired, i.e., specification or standard number, dates, amendment numbers, complete drawing numbers; also the request should identify the invitation for bid, request for proposal, or the contract involved or other use to be made of the requested material.)

**2.3 Military specification.-** The following military specification, of the issue in effect on the date of invitation for bids or requests for proposals forms a part of this specification:

**MIL-E-17555 Electronic and Electrical Equipment and Associated  
Repair Parts, Preparation for Delivery of**

(Information on obtaining copies of Military specifications is given in the SUPPLEMENT, FAA-G-2100, FAA LIST OF APPLICABLE DOCUMENTS)

**2.4 Federal specification.-** The following Federal specification, of the issue in effect on the date of invitation for bids or request for proposals, forms a part of this specification:

**L-P-383 Plastic Material, Polyester Resin, Glass Fiber  
Base, Low Pressure Laminated**

(Information on obtaining copies of Federal specifications is given in the SUPPLEMENT, FAA-G-2100, FAA LIST OF APPLICABLE DOCUMENTS)

**3. REQUIREMENTS**

**3.1 Equipment to be furnished by the contractor.-** Each antenna system furnished by the contractor shall be complete in accordance with all specification requirements and shall include the items tabulated below

for the class of antenna system specified in the contract schedule. Instruction Books in accordance with FAA-D-638 shall be furnished in the quantities specified in the contract schedule.

**3.1.1 Class 1 (Null Reference System).**- Each null reference antenna system shall include the following items:

<u>Item</u>	<u>Quantity</u>	<u>Reference</u>
Antenna Array	2	(3.8)
External RF network	1	(3.9)

**3.1.2 Class 2 (Capture Effect System).**- Each capture effect antenna system shall include the following items:

<u>Item</u>	<u>Quantity</u>	<u>Reference</u>
Antenna Array	3	(3.8)
External RF network	1	(3.9)
Clearance cancellation bridge	1	(3.13)

### 3.2 Environmental conditions and definitions

**3.2.1 Ambient conditions.**- The ambient conditions shall be those of Environment III (1-3.2.23, FAA-G-2100/1) and shall additionally include rain (4 inches/hour rate), sleet and snow (see 3.8.13 and 4.2.2.2) for the antenna arrays (3.8) and external RF networks (3.9). The ambient conditions for the clearance cancellation bridge (3.11) shall be those of Environment II (1-3.2.23, FAA-G-2100/1).

**3.2.2 Null reference glide slope station.**- The term "null reference" pertains to the two radiation patterns produced in space to develop the basic image-type glide slope. The null pattern is produced by the antenna designated as the "sideband" antenna which is located at a height above the ground plane so that in its vertical radiation pattern the first null above the ground falls at the glide slope angle. The reference pattern is produced by the antenna designated as the "carrier" antenna which is located at one-half the height of the sideband antenna so that in its vertical radiation pattern the maximum amplitude of the first lobe above ground falls on the glide slope. Thus aircraft on the glide slope will receive only the signals radiated from the carrier antenna, and when above or below the glide slope will receive combined signals from the carrier and sideband antennas. To develop glide slope angles in the range of 2 to 4 degrees, the sideband antenna is located at a height corresponding to 5160 to 2580 electrical degrees (42.4 to 21.2 feet at a frequency of 332 MHz) above the ground plane. Both above and below the on-slope line, DDM continues increasing well beyond the 0.175 DDM required to produce full scale deflection thus providing well defined course edges. A more complete description of the null reference station is contained in FAA Handbook 6750.6.

3.2.3 Capture effect glide slope station.- The term "capture effect" is taken from the manner in which the linear receiver detector circuit responds to two signals of different RF frequencies which are each within the pass band of the receiver. If one signal is stronger than the other, the detector will discriminate against the weaker signal, resulting in a much greater ratio of the detected (stronger/weaker) signals than the ratio of the signals at the input of the receiver. In the capture effect glide slope station, three antennas are utilized. The middle and lower antennas are positioned at the same height as for a null reference sideband and carrier antenna, respectively, while the upper antenna is positioned at three times the height of the lower antenna. In addition to the sideband and carrier signals (primary signals), a clearance signal separated in frequency by 8 kHz from the primary signals is fed to the antenna system. The clearance signal presents a broad null in the useable path area and therefore the glide angle and path width are functions of the primary signals only. The clearance signal effectively fills in the low angle area in which the primary signals are cancelled. Reflections of this signal from low angle discontinuities have insignificant effect on the path structure due to the aforementioned capture effect principles.

3.2.4 DDM.- The term "DDM" refers to the difference in depth of modulation of the 90 Hz and 150 Hz components applied to the RF carrier. Values of DDM are obtained by subtracting the smaller modulation percentage from the larger and dividing by 100.

3.3 General functional requirements.- The antenna system specified herein will be used to provide vertical guidance to aircraft for accurate descent to the runway threshold during approach and landing under instrument flight rules. In the null reference station, the antenna system is connected to the glide slope transmitter which has two outputs. One output delivers carrier power, amplitude modulated by 90 Hz and 150 Hz to the lower antenna; the other output delivers 90 Hz and 150 Hz sidebands only (double sideband suppressed carrier) to the upper antenna. In the capture effect station, the antenna system is also connected to a clearance transmitter. In this configuration, the modulated carrier output from the glide slope transmitter is fed to the lower and middle antennas, while the sideband only output is fed to all three antennas. The clearance transmitter output, which consists of an RF carrier separated in frequency from the glide slope transmitter by 8 kHz and modulated with 150 Hz signal only, is fed to the upper and lower antennas. The pickup devices and the associated RF networks will be used for the monitoring of the glide slope path width. The single output from this combining circuitry will feed the monitor linear detector. The glide slope antenna system will be subjected to large variations in temperature, humidity, and precipitation. Therefore, long term stability shall be incorporated into the design of this equipment by proper selection of materials, parts, components and manufacturing tolerances.

3.4 Frequency range.- The antenna system shall be designed for operation in the frequency band of 328.0 MHz to 336.0 MHz. Unless otherwise specified,

all specification requirements shall be met throughout this range without tuning, electrical adjustment or mechanical adjustment.

3.5 Characteristic impedance.- The design center impedance of the RF components and assemblies shall be 50 ohms.

3.6 Flexible coaxial cable and connectors.- Flexible coaxial cable shall be utilized for interconnections between the various assemblies of the antenna system. This cable shall be the phase stabilized version of RG-214/U (artificially aged by the cable manufacturer) and shall be fabricated from the same reel or batch of cable, having been manufactured on the same manufacturing run by the cable supplier. All coaxial cable connectors shall be Type N with captivated center conductors and contacts.

3.7 Construction of RF networks.- Strip line, Slab-line, Air Strip, or rigid coaxial assemblies (solid metal sheath) shall be utilized as appropriate for the RF networks, power divider and hybrids. The use of cable other than rigid coaxial cables for these assemblies is prohibited.

3.8 Antenna array requirements.- Each antenna array shall consist of single or multiple horizontally polarized elements combined with a reflector and an integral distribution network to meet the required gain, and vertical and horizontal pattern requirements. Antenna heaters or radomes or both may be utilized to satisfy the total requirements for operation under the environmental conditions specified.

3.8.1 Power handling capability.- The antennas shall be capable of handling 50 watts of CW RF power in the frequency range of paragraph 3.4 without physical breakdown or corona discharge.

3.8.2 Polarization.- The radiated signal of the antenna shall be horizontally polarized. The vertical component shall be at least 26 dB below the horizontal component as measured in front of the antenna and within  $\pm 25$  degrees in azimuth of a vertical plane perpendicular to the reflector and passing through the center of the antenna array.

3.8.3 Front-to-back ratio.- The front-to-back ratio of radiated signal shall be not less than 16 dB.

3.8.4 VSWR.- The input VSWR of the antenna array shall not exceed 1.20 under normal test conditions with the antennas fed from a 50 ohm line. Over the expanded service conditions defined in 3.2.1, the VSWR shall not exceed 1.30.

3.8.5 Gain.- The gain of the antenna array shall be such that the free space radiation from the antenna at zero degrees in azimuth shall be not less than 10 dB above that of a lossless isotropic radiator.

**3.8.6 Horizontal pattern requirements.**- The front hemisphere free space horizontal pattern of the antenna array when plotted as illustrated in Figure 1 shall be confined within the upper and lower limits specified thereon. The  $0^{\circ}$  reference on Figure 1 shall be the electrical axis of the array (the peak of the beam) determined as midway between the 3 dB points of the measured pattern. The electrical axis, so determined, shall not deviate from the mechanical axis by more than  $\pm 2^{\circ}$ .

**3.8.7 Vertical pattern requirements.**- The free space vertical pattern of the antenna array shall be symmetrical around zero degrees elevation and the pattern amplitude shall decrease smoothly in either direction from zero degrees elevation.

**3.8.8 Distribution network.**- A weatherproof RF network with a Type N input receptacle shall be provided for feeding the individual antenna elements of the array in the phase and amplitude relationships necessary to meet the pattern requirements of 3.8.6. This network shall be mounted in a location on the array assembly which is readily accessible for servicing.

**3.8.9 Mounting frame.**- The array antenna elements and distribution network shall be mounted on an aluminum frame. The frame shall include two flanges, equally spaced above and below the horizontal axis of the array, for mounting to 1-5/8" x 1-5/8" 'Unistrut' aluminum channels on a glide slope tower. (The channels are not required to be furnished under this specification.) Slotted mounting holes for a 3/8" bolt size shall be provided in each flange and spaced 3 inches center to center. The length of the slot shall be 7/8".

**3.8.10 Array assembly size and weight limitation.**- The weight of each completely assembled antenna array (including mounting frame) shall not exceed 60 pounds. Neither shall the maximum effective cross-sectional area when encased in 1/2 inch of radial ice exceed 1080 square inches. (This latter requirement shall apply whether or not the design utilizes heaters (3.8.12) to prevent the accumulation of ice.)

**3.8.11 Integral pickup devices and combining network.**- Each array shall include monitor pickup devices which sample a portion of the energy radiated by the individual antenna elements. The contractor shall determine the number, mounting location and coupling factor of the pickup devices that are necessary to meet the performance requirements specified in 3.10.1 through 3.10.5. The outputs of the individual pickup devices shall be combined in an RF network to provide a single output for the array, terminated in a Type N receptacle. This network shall be mounted in a location on the array assembly which is readily accessible for servicing.

**3.8.12 Radomes.**- Radomes, if utilized (see 3.8) shall be fabricated of Type III glass fibre base plastic material in accordance with L-P-383

(modifies paragraph 1-3.15.3 of FAA-G-2100/1). If radomes are utilized, all performance requirements of the antenna system shall be met with radomes installed.

**3.8.13 Antenna heaters.**- If antenna heaters are utilized (3.8) to meet the requirements for operation in sleet and snow (3.2.1), such requirements shall be deemed to have been met if the antenna heaters are successful in preventing the accumulation of snow, ice, or slush on critical surfaces of the antenna array (radiating and pickup elements, radome, if utilized, and reflector) under wind conditions of up to 50 mph at air temperatures between 0°C and -10°C.

**3.8.13.1 Heater electrical requirements.**- Heaters shall operate from 240 VAC (design center value). Total heater power for each antenna array shall not exceed 1500 watts in meeting the requirements of 3.2.1 and 3.8.13. The heater circuit shall be so isolated from the RF circuits that operation of the heater circuit does not affect the antenna VSWR, radiation patterns or the signal characteristics from the monitor pickup devices; neither shall RF energy be coupled to the heater power circuit. A suitable water-proof input connector and mating cable connector (1-3.16.3 of FAA-G-2100/1) shall be provided on each antenna array. The connector shall provide for grounding of the array frame to the third (grounding) conductor of the input power cable. The input power cable is not required to be furnished under this specification; however, the Contractor shall recommend the type of cable to be used for installation. (Cable shall be suitable for direct earth burial.) The length of cable used by the Government will not exceed 150 feet.

**3.8.13.2 Antenna array thermostats.**- One or more thermostats shall be provided in each antenna array to control the application of power to the antenna heater(s). If multiple heaters are used, the heaters and thermostats shall be wired such that power is applied to (or removed from) all antenna elements of the array simultaneously. The thermostats shall be set to operate at an (outside) ambient temperature within the range of +4°C to +10°C (including differential). The minimum differential shall not be less than 1°C. Unless it can be demonstrated that continuous application of heater power does not result in damage to any portion of the antenna array, one or more safety thermostats shall be utilized as required to provide protection in the event of failure (short-circuit) of the primary thermostat(s).

**3.8.13.3 AC contactor.**- An AC contactor shall be provided for installation (by others) in the glide slope transmitter building. The contactor coil shall operate from 120 VAC. The contacts shall be adequately rated to carry the maximum current required to operate all heaters of a Class 2 antenna system simultaneously.

**3.8.13.4 Master thermostat.**- A master thermostat with a remote bulb shall be provided for installation (by others) on the wall of the transmitter

building to sense the outside free air temperature. The contacts shall be rated to carry the current and voltage required to operate the coil of the AC contactor. A mounting bracket shall be provided. The thermostat shall operate within the range of  $-12^{\circ}\text{C}$  to  $-18^{\circ}\text{C}$  (including differential). The minimum differential shall not be less than  $1^{\circ}\text{C}$ . The thermostat contacts shall remain open at temperatures lower than the operate setting.

3.9 External RF network.- An external RF network shall be provided in accordance with Figure 2 to combine the pickup network outputs of the upper and lower antenna arrays in the null reference station or of the middle and lower arrays in the capture effect station. This network shall be housed in a weatherproof enclosure which shall be of sufficient size to permit the possible future addition by the Government of one bridge, phaser and power divider identical to those shown in Figure 2. The enclosure shall have a hinged front cover to permit easy access to the RF network components and shall be designed for mounting to  $1\text{-}5/8'' \times 1\text{-}5/8''$  'Unistrut' aluminum channels on a glide slope tower. (The channels are not required to be furnished under this specification.) All input and output receptacles shall be Type N. The two inputs and outputs of the bridge shall provide not less than 30 dB of isolation. The phaser shall have a minimum range of  $\pm 15$  electrical degrees from center position at 328 MHz with a scale calibrated at 332 MHz. The range of the power divider or attenuator shall be as necessary to meet the requirements of 3.10.2. Two coaxial cable assemblies (including connectors on each end) shall be furnished in accordance with paragraph 3.6 for use in connecting the pickup device combining network output of the individual antenna arrays to the external RF network. The cable assemblies shall be not less than 35 feet long and of the same electrical length within  $\pm 5$  degrees at 332 MHz.

3.10 Performance requirements for pickup devices and RF networks.- The requirements of the following sub-paragraphs shall be met with the pickup device combining networks connected to the external RF network in accordance with Figure 2 using the coaxial cable assemblies specified in 3.9.

3.10.1 Signal level at RF network output.- The signal level (including modulation components) as measured at the output connector of the external RF network with the DDM set for 0.350 shall be not less than 200 microwatts when the following conditions are present at the input receptacle of the antenna array distribution networks (3.8.8):

- (a) Lower antenna array - RF carrier, amplitude modulated to a depth of 40 percent each with 90 Hz and 150 Hz navigational tones, with an average power (including navigational modulation components) of 380 milliwatts.
- (b) Upper antenna array - 90 Hz and 150 Hz sidebands (double sideband suppressed carrier), with the carrier suppressed at least 30 dB and

the RF phase of the 150 Hz sidebands in phase and the 90 Hz sidebands 180 degrees out of phase with the corresponding sidebands at the lower antenna array input, having an average power in the range of 0.52 to 20.9 milliwatts.

3.10.2 DDM at RF network output.- The DDM of the signal as measured at the output connector of the external RF network shall be adjustable by means of the variable power divider or attenuator to all values within the range of 0.300 to 0.400 DDM (150 Hz predominating) with the input conditions defined in (a) and (b) of 3.10.1. This DDM range shall be achieved for all sideband input power settings within the range defined in (b) of 3.10.1. The location of the power divider (A or B of Figure 2) may be changed in order to meet the range requirements.

3.10.3 Stability of signal level at RF network output.- With the input conditions ((a) and (b) of 3.10.1) maintained constant, the signal level measured at the output connector of the RF network shall remain constant within  $\pm 2$  dB when the antenna system is subjected to the service conditions defined in 3.2.1.

3.10.4 DDM stability at RF network output.- With the input conditions ((a) and (b) of 3.10.1) maintained constant, the DDM measured at the output connector of the RF network shall remain constant within  $\pm 0.010$  DDM after initial adjustment to 0.350 DDM when the antenna system is subjected to the service conditions defined in 3.2.1. The requirement shall apply over the range of sideband power settings defined in (b) of 3.10.1.

3.10.5 Response to open and short circuits in arrays.- The pickup devices and associated RF networks shall be designed to detect changes in the radiated signal of either antenna array due to short or open circuits in the distribution network (3.8.8) or in the individual dipole elements. Any such open or short circuit condition resulting in a measured reduction in the radiated signal on the antenna array center axis shall produce a change in DDM at the output of the external RF network (3.9) which is within 5 percent of the DDM change produced when the input power to the array (with distribution network and dipole elements normal) is reduced to provide the same measured reduction in radiated signal.

3.11 Clearance cancellation bridge.- A clearance cancellation bridge shall be provided with each Class 2 (capture effect) antenna system in accordance with the following sub-paragraphs.

3.11.1 Electrical requirements.- The cancellation bridge (Figure 3) shall consist of a fixed hybrid bridge with terminating resistor and adjustable phaser. The bridge shall provide not less than 30 dB of isolation. The phaser shall provide a minimum range of adjustment of  $\pm 15$  electrical degrees from center position at 328 MHz with a scale calibrated at 332 MHz. All input and output receptacles shall be Type N.

3.11.2 Physical requirements.- The cancellation bridge components shall be mounted on the rear surface of a rack panel-door. The rack panel-door shall be Type I of FAA-G-2300, less the vertical chassis (paragraphs 3.9 through 3.9.2 of FAA-G-2300 are not applicable). The maximum panel size shall be size C (Drawing D-21140).

3.12 Painting.- Exterior metallic surfaces of the antenna arrays (3.8) and external RF networks (3.9) shall be painted in accordance with FAA-STD-012. The paint color for the antenna arrays shall be international orange (No. 12197 of Federal Standard 595). The paint color for the external RF networks shall be white (No. 17875 of Federal Standard 595). The exterior metallic surface of the clearance cancellation bridge (3.11) shall be painted in accordance with 1-3.8.2 of FAA-G-2100/1.

3.13 Nameplates.- Separate nameplates (1-3.13 of FAA-G-2100/1) shall be furnished on each antenna array, external RF network (3.9), and clearance cancellation bridge (3.11). Equipment titles shall be GLIDE SLOPE ANTENNA, GLIDE SLOPE WIDTH MONITOR RF NETWORK, and GLIDE SLOPE CLEARANCE CANCELLATION BRIDGE, respectively.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 General.- See Section 1-4 of FAA-G-2100/1.

4.2 Design qualification tests.- In addition to the tests specified in 1-4.3.2 of FAA-G-2100/1, the following design qualification tests shall be conducted.

4.2.1 Normal condition tests.- The following tests shall be conducted under normal test conditions (1-3.2.22 of FAA-G-2100/1) except where indicated.

3.2.1	Wind and ice loading (1-4.10 of FAA-G-2100/1)
3.8.1	Power handling capability (332 MHz)
3.8.2	Polarization (328 MHz, 332 MHz, 336 MHz)
3.8.3	Front-to-back ratio (328 MHz, 336 MHz)
3.8.4	Input VSWR (328 MHz, 336 MHz)
3.8.5	Gain (328 MHz, 336 MHz)
3.8.6	Horizontal pattern (328 MHz, 336 MHz)
3.8.7	Vertical pattern (328 MHz, 332 MHz, 336 MHz)
3.8.13.2	Overheat protection (276 VAC)
3.10.5	Response to open and short circuits (332 MHz)

4.2.2 Design qualification tests under the service conditions.-

4.2.2.1 Rain test.- The following tests shall be conducted under simulated rain conditions (4 inches/hour). (Tests shall be conducted at 332 MHz.)

- 3.8.4 Input VSWR
- 3.10.3 Stability of signal level
- 3.10.4 DDM stability

4.2.2.2 Snow, sleet, and ice.- A test shall be conducted to demonstrate the ability of the antenna arrays to perform satisfactorily in accordance with specification requirements under conditions of accumulated ice and snow. The criteria for satisfactory operation shall be as in 4.2.2.1 above.

As an alternate to the above procedure, the contractor may conduct a controlled environmental test duplicating the conditions of 3.8.13 (-10°C and 50 mph wind) with moisture laden air impinging on the antenna array surface to demonstrate that there is no perceptible formation of ice on critical antenna surfaces (3.8.13). This test shall be conducted with antenna heater systems (if utilized) operative.

4.3 Type tests.- The following type tests shall be conducted.

(a) Under normal test conditions

- 3.8.3 Front to back ratio (332 MHz)
- 3.8.5 Gain (332 MHz)
- 3.8.6 Horizontal pattern (332 MHz)
- 3.9 Phaser range
- 3.11.1 Isolation
- 3.11.1 Phaser range

(b) Under service conditions

- 3.8.4 Input VSWR
- 3.10.3 Stability of signal level
- 3.10.4 DDM stability

For purposes of conducting the service condition tests, the procedure of paragraph 1-4.12 of FAA-G-2100/1 shall be modified to delete all intermediate temperature observations. After each stabilization period (-50°C, +70°C, and +70°C with humidity soak) the antenna array shall be removed to a reflection free site and the measurements accomplished as rapidly as possible.

4.4 Production tests.- The production tests listed below shall be conducted.

- 3.8.4 Input VSWR (328, 332, 336 MHz)
- 3.8.13.2 Operation of thermostats
- 3.8.13.4 Operation of thermostats
- 3.9 Cable length
- 3.10.1 Signal level at RF network output (332 MHz)
- 3.10.2 DDM at RF network output (332 MHz)

5. PREPARATION FOR DELIVERY

5.1 General.- Unless otherwise specified in the contract, the equipment shall be prepared for domestic shipment in accordance with the following paragraphs.

5.2 Packaging.- Packaging shall be in accordance with specification MIL-E-17555, Level A.

5.3 Packing.- Packing shall be in accordance with specification MIL-E-17555, Level B. No more than one antenna system and associated items shall be packed in each shipping container.

5.4 Marking.- Each package and each shipping container shall be durably and legibly marked with the following information:

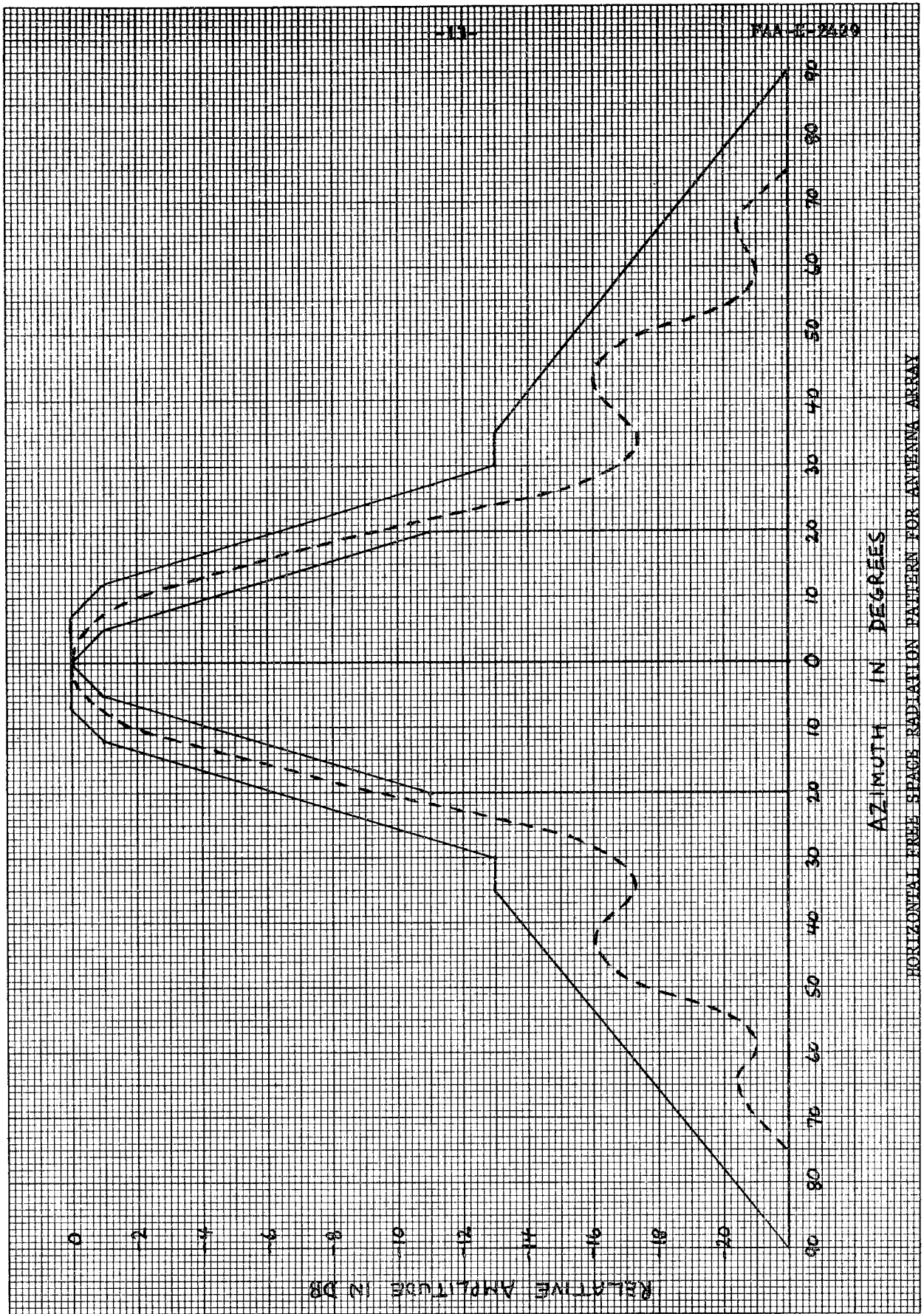
Name of Item and FA Type Designation  
Serial Number(s)  
Quantity  
Contract Number  
Federal Stock Number  
Gross Weight of Container  
Manufacturer's Name

6. NOTES

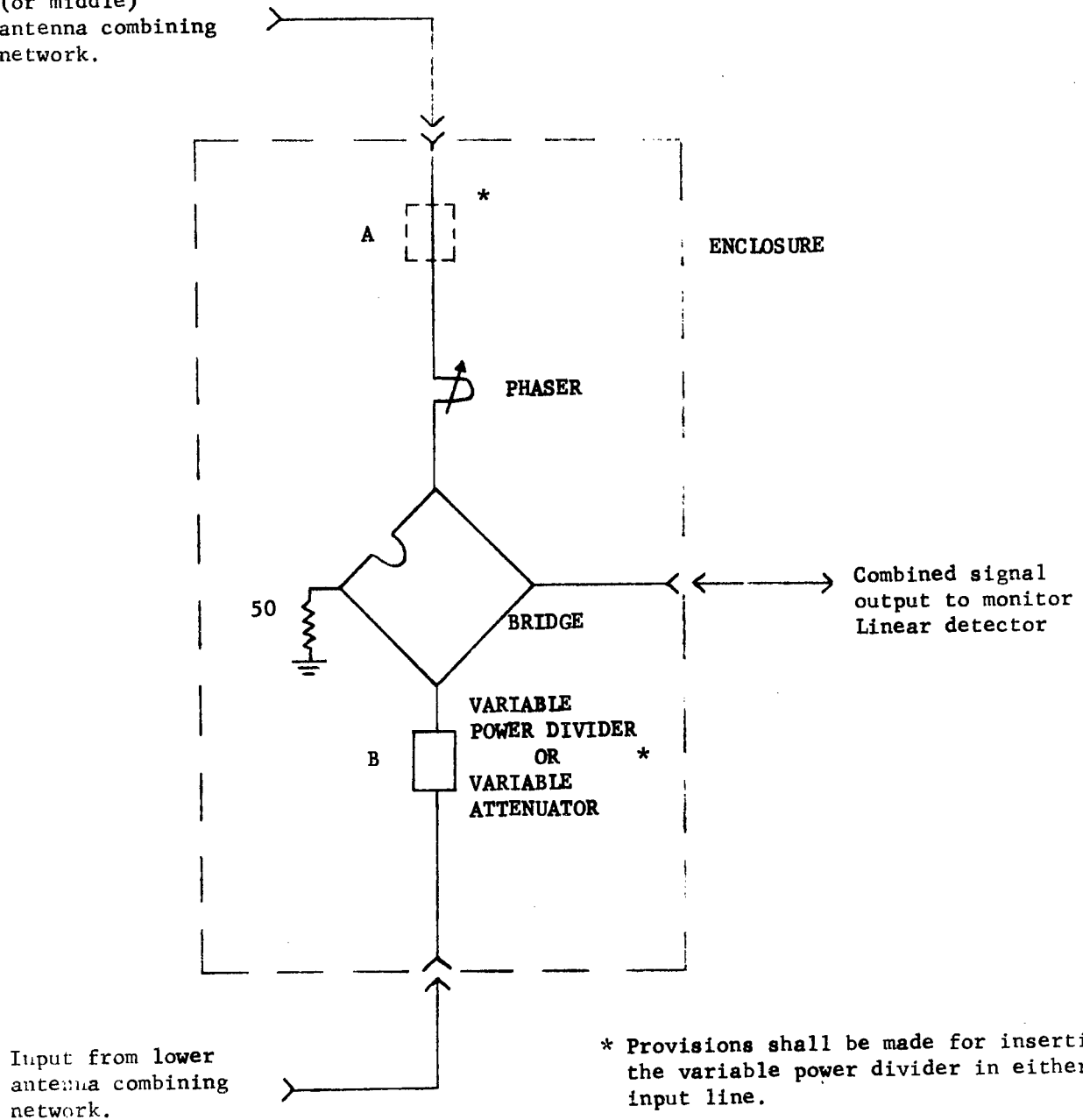
6.1 None

\* \* \* \* \*

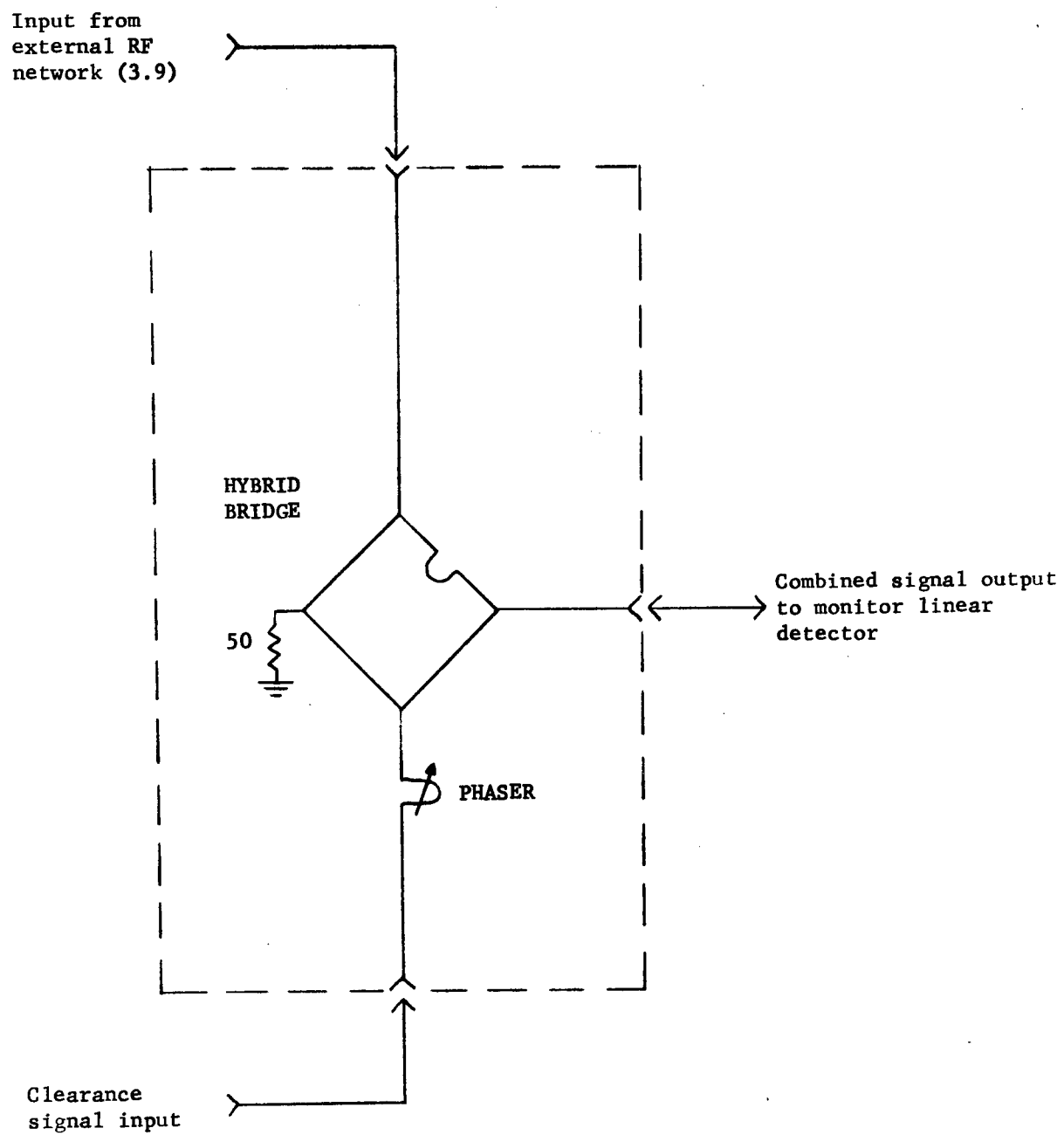
FOR FIGURES 1 TO 3, SEE PAGES 13 TO 15



Input from upper  
(or middle)  
antenna combining  
network.



EXTERNAL RF NETWORK FOR USE IN PATH WIDTH MONITORING  
FIGURE 2.



CLEARANCE CANCELLATION BRIDGE  
FIGURE 3.

